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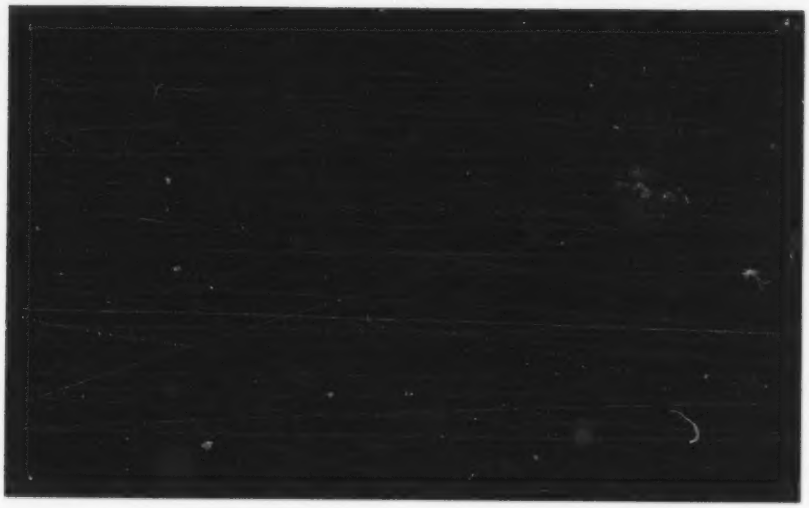

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JET-SET/2
AN INTERCITY PASSENGER TRANSPORTATION SIMULATION GAME
Operating Rules

by

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ABSTRACT

JET-SET/2 is the second version of a micro-computerized simulation game which deals with different intercity passenger transportation companies in a competitive environment, whether it be regulated or not. It is designed for the training of planners and managers as well as for the analysis and experimentation of situations similar to those encountered in practice in this sector of the transportation industry.

This document presents the operation and rules of the simulations which can be executed with JET-SET/2. It is addressed to anyone embarking on a simulation, either as a participant in charge of one of the companies involved, or as the game master responsible for the running of the simulation.

Key words : intercity passenger transportation; planning; management; simulation game; training; experimentation.

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RÉSUMÉ

JET-SET/2 est la seconde version d'un logiciel de simulation d'entreprises de transport interurbain de passagers en concurrence les unes avec les autres, dans un environnement réglementé ou déréglementé. Conçu sous la forme d'un "jeu de simulation" sur micro-ordinateur, il est destiné à la formation de planificateurs-gestionnaires ainsi qu'à l'analyse et à l'expérimentation de situations comparables à celles rencontrées en pratique dans ce domaine.

Ce document décrit les règles de fonctionnement des simulations réalisables avec JET-SET/2. Il s'adresse à ceux qui veulent participer à une séance de simulation, soit à titre de participant responsable de l'une des compagnies de transport impliquées dans la simulation, soit à titre de maître de simulation responsable du déroulement de la séance de simulation.

Mots-clés : transport interurbain de passagers; planification; gestion; jeu de simulation; formation; expérimentation.

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1. INTRODUCTION

JET-SET/2 is the second version of a simulation game dealing with intercity passenger transportation companies competing in a regulated or deregulated environment. It is designed for the training of planners and managers, as well as for the analysis and experimentation of situations comparable to those encountered in practice in the field.

This document describes the operating rules of the simulations which can be executed with JET-SET/2. It is addressed to those wishing to engage in a simulation session either as a participant in charge of one of the transportation companies involved, or in the role of game master responsible for the running of the simulation.

JET-SET/2 runs on the IBM PC family of computers, including the XT, AT and PS/2, along with all true compatibles, under PC-DOS 3.0 or greater or MS-DOS 3.0 or greater. An accompanying document, called the User's Manual, explains the operating procedures for running the various software programs: operating sequence, diskette handling, possible recourse to the hard disk, and dialogue with the user.

The present document need not be read by all those participating in a simulation. The game master may replace it orally by explaining the workings of the simulation, and answering any questions arising. Nevertheless, the game master's job will be simplified if he gives the participants a copy of the present document, possibly specifying the various sections of the text most useful to them; for all practical purposes, only section 3 can actually be considered essential for those desirous of participating in a simulation for the first time.

2. DESCRIPTION OF THE SIMULATOR

2.1 GENERAL PRINCIPLES

The JET-SET/2 software was conceived in the form of a "simulation game" which sets various intercity passenger transportation companies in competition against each other. All modes of public transport may be present: rail, road (bus) and air. The private mode of transport which the automobile provides is also considered.

At the beginning of a simulation session, each participant (or team of participants) "receives" a company which serves a certain number of cities, and he becomes the administrator or manager of that company. In this capacity, each participant is called upon to make diverse decisions concerning his company: choice of services and fares, purchase or leasing of vehicles, marketing, bank loans, etc... These decisions are made at the beginning of different consecutive periods, each representing one year, and they are based on the information contained in an annual report received at the end of each preceding period (year).

The information provided in each participant's report at the end of each year summarizes the activities of his company in the last twelve months and describes the markets and the economic and commercial environment in which the company was operating, particularly those aspects concerning the competition with other companies. This information constitutes the means by which each participant can analyze his performance and make new decisions for the next year, thus trying to gradually improve the performance of his company (reduce his operating costs, expand his share of the markets, etc...) as he experiences the effects of his successive decisions.

The game master is responsible for the running of the simulation session and orchestrates the evolution of the economic context in which the companies operate. In particular, he has the power to modify certain

indicators, like the population growth rates in the cities under consideration, the interest rates, the level of government subsidies to the companies, etc. He also has the possibility of making choices about regulation, possibly imposing restrictions on entering or leaving markets and imposing constraints on authorized variations in fares and frequencies of services. At the end of each year, the game master also receives a report which permits him to follow the developments in the group of companies.

The computer program which constitutes the heart of JET-SET/2 is the means by which the artificial environment is created in which the different companies simutaneously meet. This program reproduces the multi-modal and multi-company network thus established, it simulates the behaviour patterns of passengers in the network, as well as the operations of the companies and the changes in their market shares, and it determines their revenues and their operating costs. Each execution of the program reproduces one year of activities of all companies, simulating the effects of the participants' decisions and of the choices made by the game master.

One simulation session thus covers a series of years simulated according to decisions taken each year, so that the evolution of each company depends directly on the participant who represents it, but also, indirectly, on the presence of the other companies and on the economic and regulatory context. JET-SET/2 models fictitious but realistic situations so as to provide participants with a comprehensive understanding of the interactions between different transportation modes and companies, as well as of the interactions and major effects of certain decisions in terms of planning and management. The objective is to develop among the participants a better understanding of market mechanisms relevant to the intercity passenger transportation industry, as well as an improved capacity to analyze and make decisions in this field.

The general philosophy that each participant should adopt is the one motivating real planners and managers of intercity transportation companies: to progressively draw up a supply policy and an operation strategy which take into consideration the evolution of the markets, the position his company occupies in these markets, and the company's financial health.

A complete simulation session can cover a maximum of 20 consecutive periods (years), but, in general, a typical session takes from 4 to 7 periods. The actual time spent in the simulation session depends on the context in which JET-SET/2 is used and the time granted to participants by the game master to prepare their decisions. It depends also on the work required of participants to justify these decisions. As an example, it is possible to concentrate a session of 4 to 6 simulated years within two days, allowing 2½ to 3½ hours for each year (roughly 1½ to 2 hours for the preparation and entry of decisions, 1 to 3 minutes for the execution of the simulation, and about 1 hour to print the reports). Other users may prefer to spread the simulation session over several weeks, simulating one year each week.

It is important to underline that JET-SET/2 can serve for the sole purpose of training and experimental analysis, and in no way as a planning or management tool in a real situation. The role of JET-SET/2 is limited to the simulation and analysis of imaginary but possible situations, that is, situations where the inherent mechanisms are perfectly comparable to those of real situations, nothing else.

JET-SET/2 was programmed in PASCAL and is user-friendly.

2.2 GAME SITUATIONS

JET-SET/2 involves seven cities, which form 21 markets (pairs of cities), and a maximum of six intercity passenger transport companies, which, from the start of a simulation session, supply transportation services between some of these cities.

The game master chooses one of the following three situations.

Situation 1

Normally, this situation involves 6 participants, each responsible for one of the following 6 companies:

- a standard rail company
- a rapid rail company
- two bus companies
- a standard airline company
- a STOL[1] airline company.

If there are fewer than 6 participants, the companies corresponding to the absent participants can stay in the game, or can be completely eliminated from the simulation. The game master can also keep only some of those companies in the game. Those that are kept without participants to manage them stay "fixed" during the entire simulation session, constantly offering the same services at the same fares.

The companies managed by the participants and those which possibly stay "fixed" are in competition with each other and with the private transportation mode offered by the automobile.

Situation 2

Normally, this situation brings into play 4 participants, each responsible for a bus company. A standard rail company and a standard airline company are also normally present, but these two companies are never managed by participants: if they are present, they remain "fixed" during the entire simulation (services and fares constant). The game master can also eliminate these two companies from the simulation, or keep only one of them.

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[1] Short Take-Off and Landing airplanes are smaller and less rapid than standard ones. They generally use airports very near city centers, i.e. airports which are accessible rapidly and at a low cost.

If there are fewer than 4 participants, the bus companies corresponding to the absent participants can stay in the game, or they can be completely eliminated from the simulation, or only some of them may be kept in play. Those which remain without participants to manage them stay "fixed" for the entire simulation (services and fares constant).

The bus companies managed by the participants and the bus companies which possibly stay "fixed" are thus in competition with each other on a first level, that is, within the bus sector of the transport industry, and possibly on a second level with one or two of the other modes of transport (rail/air) represented by one or the other two companies which remain "fixed". The automobile mode is also always present.

Situation 3

This situation, differing from the other two, involves a maximum of 4 participants. These participants, however, are not in direct competition with one another in the markets under consideration. Instead, they are in charge of the same company in the same initial conditions, namely a bus company, and these 4 companies are managed at the same time, in "parallel" identical contexts where normally there are 5 other "fixed" companies (services and fares constant): a standard rail company, a rapid rail company, one other bus company, a standard airline company and a STOL airline company. One or more of these 5 other companies can be completely eliminated from the simulation. The automobile mode is also always present.

In other words, everything takes place as if each participant (four or fewer) were in charge of one of the bus companies of situation 1, the other selected companies remaining "fixed" through the simulation session. The objective is to compare the performance of participants operating in parallel identical contexts at the same time.

In Summary

At the beginning of a simulation session, the game master has the choice between 3 situations. In situation 1, six companies representing the three modes of transport (rail, bus, air) are normally present in the simulation for six participants. In situation 2, four bus companies for four participants and two other companies representing the other modes of transport (rail, air) are normally present. In situation 3, a bus company for a maximum of four participants working in parallel is always present, and another bus company with four other companies representing the other modes (rail, air) are normally present.

Whatever situation is being considered, any of the companies normally present can be eliminated, and those that are effectively kept in the simulation are either managed by participants or "fixed" during the entire simulation. The automobile mode is, moreover, always present.

2.3 RUNNING OF A SIMULATION SESSION

The running of a simulation session is very simple and has, in fact, already been outlined in section 2.1. It covers a succession of years, each one treated in three stages[1]: input of decisions made by participants and the game master, execution of the simulation program, and output (printing) of activity reports.

In Figures 1 and 2, flow charts schematize the running of a simulation session, respectively for situations 1 and 2 and for situation 3. The sequence of operations is briefly summarized below.

At the beginning of a simulation session and at the end of each simulated year, that is, after each execution of the simulation program, a report is handed out to each participant to inform him about the activities and the

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[1] Except in the case of the year zero for which just the last 2 stages are required.

performance of his company during the year which has just ended; information is also given about the services supplied by the other companies, and about the economic environment, etc. This activity report also includes a list of decisions to be made for the coming year.

Similarly, at the end of each year, the game master receives a report. This document informs him about the state of the markets and the different companies, and it includes a list of decisions to be made regarding the evolution of the economic context, and possibly the regulatory one (see section 2.4).

The year at the beginning of which the participants and the game master make their very first decisions is designated year 1. Thus the first reports that the game master must print out and deliver to the participants at the outset of a simulation session are the reports of the year 0.

The decisions of the participants and of the game master are entered on the display screen of the micro-computer by means of a question-answer dialogue between the software and the operator. Normally, the game master plays the role of operator: after collecting the participants' decisions, transcribed at the end of their respective reports, it is the game master who enters these decisions and his own into the computer. Nevertheless, by following simple procedures described in the User's Manual, each participant can easily enter his decisions himself. The one restriction is that the Master's decisions must always be entered before those of the participants.

The function of the simulation program – which is run under the sole responsibility of the master – is to simulate the combined effects of all decisions on the state and the evolution of the transport system. After the

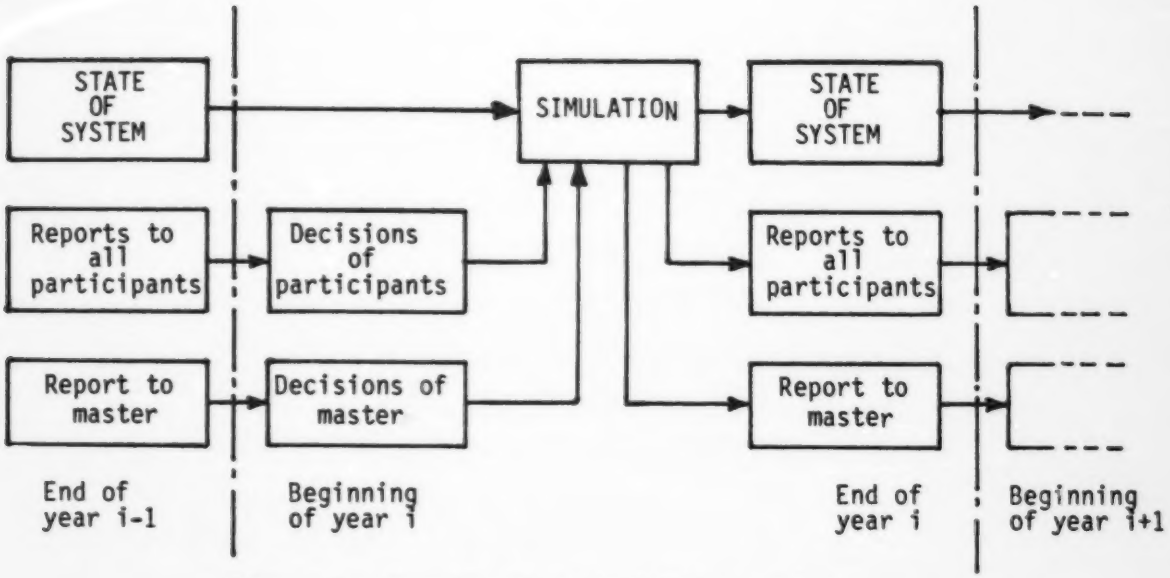

Figure 1 : Running of a simulation session.
Situations 1 and 2.

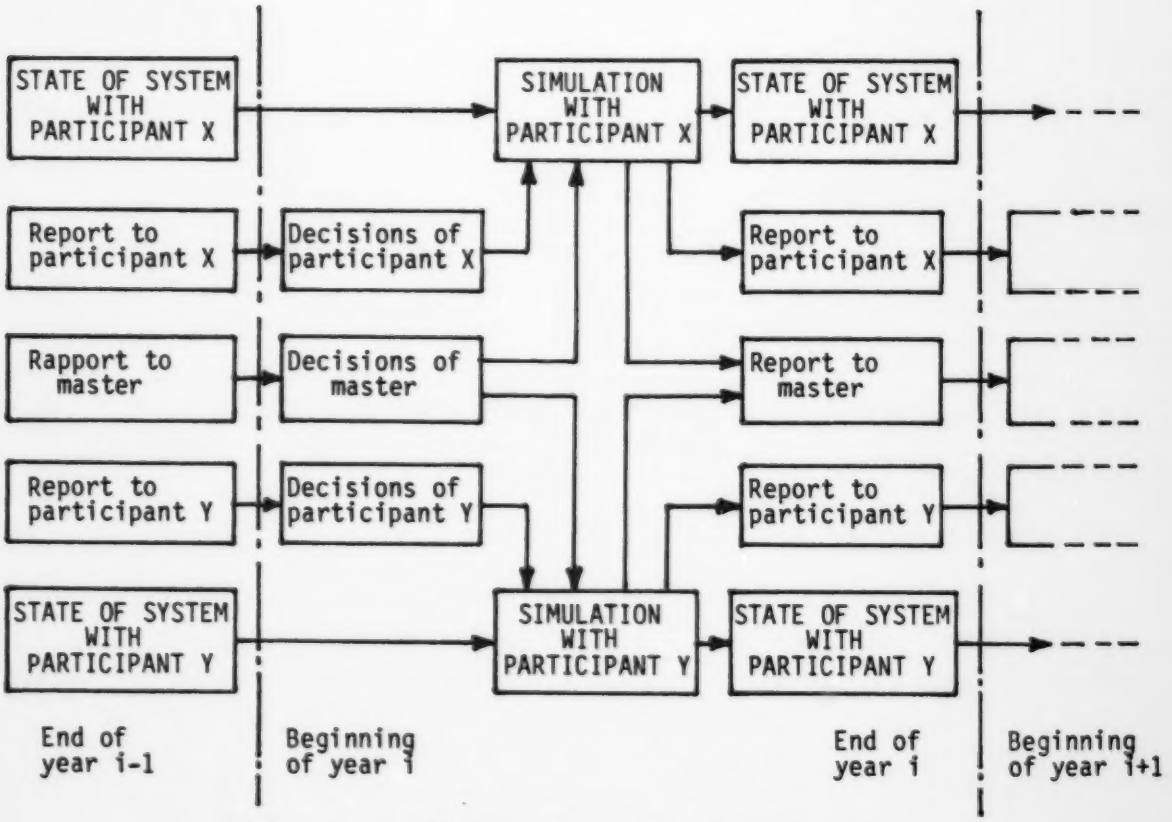

Figure 2 : Running of a simulation session.
Situation 3.

program is run, each company finds itself in a new position corresponding to the state of the system one year later. New reports are then produced for each participant and for the game master, and so on.

We must specify that in the case of situation 3 where participants operate in "parallel" contexts (Figure 2), the game master has to run the simulation program as many times as there are participants since a different "state of the system" corresponds to each participant. In situation 3, the state of the transport system corresponding to each participant evolves independently of the others. (The master's decisions, however, are common to all the different contexts in which the participants evolve: the master's decisions are made once at the start of each year and they apply in the same fashion to all different parallel simulations.)

Finally, we must also specify that, generally, it is the game master who ensures that all the reports are produced on the printer. However, as with the decision input stage, he can delegate to the various participants the production of their own respective annual reports.

2.4 REGULATION VERSUS DEREGULATION

At the start of a simulation session, the game master has to decide whether he wants to impose a regulatory framework on the different companies under consideration, or, on the contrary, opt for total deregulation. Accordingly, the entire simulation will thus be either regulated in conformity with the master's decisions in this respect, or totally deregulated.

In the case of a regulated simulation session, a participant can modify the fares and frequencies of the services supplied by his company, provided that he respects the constraints on the variations permitted in these fares and frequencies. The game master can modify these constraints during the simulation session.

Moreover, in such a regulated context, no participant may freely enter or leave the markets: he may never provide a service to a pair of cities that his company is not serving at the starting year, nor, on the other hand, may he completely cancel services between two cities which are served by his company (he must maintain a minimum frequency of service of one trip per day).

In a deregulated simulation session, there are no constraints on fares and frequencies of services, and the participants may freely enter and leave any market at any time, that is provide services to new city pairs or completely cancel services.

2.5 TRANSPORTATION SUPPLY AND DEMAND

2.5.1 Simulation of Trips

The demand for transport between two cities depends on their socio-economic characteristics, and especially on their respective populations. It also depends on the distance between the cities and the transportation services supplied (modes, travel times, fares and frequencies). In terms of round trips, the demand is not symmetrical: the number of persons inhabiting city A who travel to city B and then return to A is not necessarily the same as the number of persons who inhabit B and take B-A-B trips. For a transportation company, however, knowing true origins and destinations of trips is not really essentiel; what counts is the movement of persons from each city to each other city, without necessarily making a distinction between going and returning. As regards to these movements, they are symmetrical since every "going" from A to B entails a "returning" from B to A and vice versa. In other words, the demand for transportation from A to B (some people going to B and others returning to B) is equal to the demand for transportation from B to A (some people going to A and others returning to A).

However, this symmetry of movements is strictly true only if a long period of time (several days) is considered and if the demand is assumed to be constant in time. In reality the demand undergoes daily variations, as well as weekly and seasonal variations, and the supply of services should vary according to these fluctuations.

To simplify reality, a year in JET-SET/2 is considered to be composed of 365 identical days in terms of supply and demand, but to take into account the variations which, in reality, affect the daily demand, the daily capacity supplied on each intercity link is considered saturated at 90%, that is, when the average demand for that link reaches 90% of the link's capacity.[1]

In summary, in JET-SET/2:

a) the 365 days of the year are identical;

b) the daily demand is symmetrical for each pair of cities: the number of movements each day from A to B is on the average equal to the number of daily movements from B to A;

c) the supply of transport is also symmetrical: travel times, daily frequencies and fares from A to B are identical to those from B to A;

d) the capacity of services supplied between two cities by a company is considered saturated when the average passenger traffic reaches 90% of this capacity.

Furthermore, when simulating the behavior of travelers on the transportation network made up of the group of companies and the automobile mode, one takes into account not only all direct movements between each pair of cities, but also all possible movements (itineraries) through one or two intermediate cities, with or without a change of company or mode of travel in these transit cities. For example, a trip from city A to B may correspond to a movement from A to C by bus, then from C to D by plane, then from

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[1] This means that, for an average daily demand of 100 on a given link, the following relation must be satisfied: capacity x 0.9 > 100. In other words, one must supply services with a capacity > 100/0.9 to absorb the variation in demand from one day to another.

D to B by train. However, we assume that there are at most two transit cities within an itinerary. Moreover, if the automobile mode is utilized, we assume it is used from the beginning of the journey to the end.

Lastly, the supply of transport being symmetrical, it is assumed that the route taken by a traveler to go from A to C (for example from A to B by company X, then from B to C by company Y) is taken in reverse order exactly for the return trip from C to A.

2.5.2 Variations Within the Same Day

Within any day, the demand for transportation is also, in reality, characterized by important variations to which the supply should normally adapt, especially during morning and evening peak hours.

To simplify the simulations without sacrificing realism, JET-SET/2 does not explicitly simulate these variations, but the participants must assume that, at the level of the whole network of each company: 1/3 of the daily hours of service is supplied in the morning, and lasts 3 hours and 30 minutes (for example, from 7:00 to 10:30); another 1/3 is supplied at the end of the afternoon, and also lasts 3.5 hours (for example from 16:00 to 19:30); the remaining 1/3 is distributed over the rest of the day.

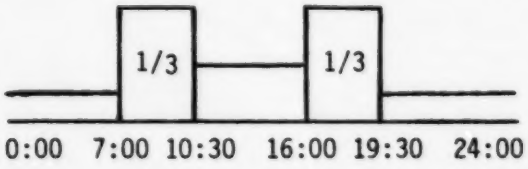

Figure 3: Distribution of the supply of services during the day.

Figure 3 schematizes these daily rush hours in the supply of services corresponding to the peak periods of demand, morning and evening. Participants must be aware of these variations when they estimate the number of vehicles needed to ensure the services supplied; if indeed we assumed a uniform distribution of the same total number of hours of service, the number of vehicles required would be smaller than that actually necessary during the peak periods.

2.5.3 Business Trips and Other Trips

JET-SET/2 takes into consideration two categories of trips: business trips on the one hand, and trips of all remaining types on the other (visits to relatives and friends, tourist or leisure trips...). These two categories of travelers respond differently to service features offered by the different transport companies: business travelers are more impressed by the speed and frequency of service, whereas, on the other hand, the "other" travelers tend to respond most to questions of fares.

The proportions of these two categories of travelers vary from one pair of cities to another, reflecting the socio-economic differences between different pairs of cities: the existence of a greater proportion of business trips between cities A and B than between two other cities presumes that the type and level of economic activities in A and B produces, relatively, more travel for business reasons.

The influence of the existence of two categories of travelers on the passenger traffic and market shares of each company is not enormous, but neither is it negligeable. The participants should thus take into account this influence, since the proportions of the two categories can vary greatly from one city pair to another, and the two groups of travelers behave differently.

2.6 ACTUALIZATION OF FINANCIAL DATA AND ABSENCE OF INFLATION

The financial data of the software is given in 1990 dollars. However, when the software is utilized in another year, that is, after 1990, the game master can index the financial data at the start of any simulation session specifying the rate of indexation of that year compared to 1990.

Once this rate is established, the entire simulation runs without any inflation, that is to say, in constant dollars. If the indexation rate has been set at zero, the simulation will run in 1990 dollars; if the rate has been set at a value other than zero, the simulation will run in dollars of the year considered.

2.7 CHOICE OF UNIT OPERATING COSTS

JET-SET/2 makes a distinction between two classes of operating costs[1]: that is, for each company, energy costs on the one hand, and all "other costs" on the other (equipment, maintenance, administration, etc.). For the automobile mode also (see Appendix 2), there is a distinction between fuel costs and other costs (insurance, maintenance, ...).

At the beginning of each simulation session, all unit operating costs (expressed in 1990 dollars or dollars of another year according to the selected rate of indexation) can be consulted and modified on the display screen by the game master. After consultation/modification, those in the "other costs" category will stay constant during the whole session, while those in the "energy costs" category will possibly change each year in accordance with the game master's decisions about the energy price.

3. ANNUAL REPORTS GIVEN TO PARTICIPANTS

We present below various commentaries useful in understanding the activity reports given to each participant at the end of each simulation year. Unless otherwise indicated, all the information contained in such a report concerns the year just ended.

Each activity report starts with three graphs. The first, entitled "Road and Rail Infrastructure", schematizes the roads and the railway lines between the 7 cities in JET-SET/2. These road and rail links are assumed to exist simultaneously: if there is a road, there is a railway line and vice versa. In a deregulated game situation, all these links may be used by trains and buses. They are also, obviously, the only links used by cars.

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[1] These are "regular costs", that is, excluding costs of additional services possibly supplied to travelers (see section 3.7.3).

In a regulated situation, each rail and bus company must, and can only, serve a subgroup of these surface links, and each airline company must, and can only, operate some of the possible air links. This subgroup of "forced" links is defined for each company by the service links it provides at the beginning of the simulation session (end of year 0); this subgroup varies from one company to another, but remains constant for each company, and the company can never withdraw from the arrangement. This subgroup corresponds, in fact, to the schematic network on the third graph.

The second graph, entitled "Complete Service Network", represents the network of all transport services supplied by all the companies during the year. In a deregulated situation, this graph can change each year. In a regulated situation, however, it never changes. This graph is identical in all participants' reports, except in the special case of a deregulated situation number 3, where it may change in a different way in each parallel simulation (see Figure 2).

The third graph in each participant's report, entitled "Network of xxx", schematizes the network of services supplied by the company xxx of this participant during the year. In a deregulated situation, the graph can change each year. In a regulated situation, it never changes.

The commentaries in the rest of this chapter follow the sequence of tables and other information contained in the reports.

Remarks : 1) The format of reports given to participants and the game master assumes the presence of 6 companies in each simulation. If there are fewer than 6 companies in play (see section 2.2), the sections of the tables corresponding to the absent companies will be completely blank.

2) Several calculation results are presented "rounded off" or "converted into integers", but are in fact utilized in their exact values in other calculations. Slight disparities may thus result. For example, the result of a calculation may be 3.808 and given out as 3.81; however, if this result is multiplied by 1000, it is the value of 3808 that may appear, and not 3810.

3.1 GENERAL DATA

3.1.1 Identification of Cities

In the tables, cities are identified by the first letter of their names.

3.1.2 Identification of Companies

Companies are identified by their name and the type of service they supply.

3.1.3 Demography

The table under this heading defines the population level of each city, its rate of variation since the preceding year[1], and also the proportion of anglophones who live there[2].

3.1.4 Direct Services Supplied by all Companies, and Corresponding Data for the Automobile

The first information on each page of this table presents the flying distance between all cities, as well as the approximate road and rail distance. These latter figures, when they exist, are assumed to be 10%

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1 That is to say, the rate of variation between the year just finished (the year described in the report) and the preceding year.

2 In bilingual countries like Canada, the linguistic differences between cities partially explain observable differences in intercity travel.

greater than the corresponding flying distances; if no information is provided about the road and rail distance between two cities, that simply indicates that direct road and railway lines do not exist between the two cities.

The table then specifies the services supplied by all the companies to the different markets (pairs of cities) in terms of fare, frequency, and travel time. These services are identical in either direction.

In a regulated situation, each company serves 6 of the 21 pairs of cities and continues to do so during the entire simulation session: the spaces left blank in the table, in rows corresponding to a company, correspond to pairs of cities that this company can never serve even if it would be physically possible, that is to say, even if, in the case of a railway company for example, the tracks are there. Conversely, the boxes specifying fares, frequencies, and travel times correspond to pairs of cities that the company must always serve.

In a deregulated situation, each company similarly serves 6 pairs of cities at the start of a simulation session (year 0), but afterwards the company can completely cancel these services, or, on the contrary, can decide to serve city pairs that it does not serve at the outset of the simulation. In the table, the boxes filled in with zeros, in rows corresponding to a company, correspond to pairs of cities that the company does not serve but could serve if it decided to. The boxes that are left blank correspond to pairs of cities that the company can never serve because it lacks the infrastructure (absence of roads and railway lines).

In summary, whether or not the simulation session is regulated, the participants do not have to concern themselves with the blank spaces in the table: the companies do not have access to the city pairs that correspond to these blank spaces (because of a lack of infrastructure and/or because

of regulation). As for the spaces filled in by zeros, in the eventuality that they appear, they only do so in deregulated simulations to indicate to companies the markets these companies are not presently serving but could serve.

The travel time given in the table is the time from one terminal to the other. It does not include the access and egress times needed to reach and leave the transportation network, that is, the time from the point of origin to the departure terminal and the time from the arrival terminal to the actual destination.

These access and egress times, as well as the corresponding costs are, however, considered in the simulation of the travelers' choices and behavior. Moreover, for itineraries which involve passing through intermediate cities[1], the simulation takes into account the waiting time between one service and the next, as well as the transfer cost if there is a change of terminal. In Appendix 1, these supplementary travel times and costs borne by travelers, in addition to the actual travel times and fares, are discussed in more detail.

The final data at the foot of each page of the table concerns the automobile, that is, the costs and time of transportation incurred by motorists, assuming an average speed of 77 km/hr. These costs are divided in two parts: on the one hand, fuel costs, and on the other hand, all the other costs which motorists should take into account (maintenance, depreciation, insurance, registration, etc.). In the simulation of the travelers' decisions about their mode of transportation, it is assumed that 10% of these "other automobile costs" are taken into account over and above the cost of fuel. Appendix 2 provides more details.

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[1] We assume that there are at most two intermediate cities along any indirect itinerary.

3.1.5 Economic indicators

These indicators provide a general picture of the economic context prevailing during the year. They are used in the calculation of interest paid and received by the companies, as well as in the calculation of the companies' taxes.

3.2 TECHNO-ECONOMIC FEATURES OF THE COMPANY

Each company has at its disposal only one type of vehicle. In the rail companies, a vehicle is an entire train.

The data provided under this heading describes the main technical and economic features of the participant's company. All this data is constant during the entire simulation, except the cost of energy which can vary from one year to the next. The costs presented here are regular unit costs: they do not include the costs of possible additional passenger amenities supplied by the company (see section 3.7.3).

The lease cost for vehicles leased-in is that of a "normal" leasing, that is, a leasing freely decided by the participant. In certain cases, the rate is tripled: this increase occurs when a "forced" leasing is automatically imposed on a participant who has not planned for a sufficient number of vehicles to ensure the services being provided.

3.3 OPERATING DATA

3.3.1 Utilization of Services

This section presents a general view of the passenger traffic and the rate of occupancy of the vehicles (load factor) on all service links supplied by the company. A reminder: vehicles are considered saturated at 90% of their capacity (see section 2.5.1).

3.3.2 Vehicle Fleet

The total number of vehicles at the disposal of a company over one year includes on the one hand the vehicles the company owns, and, on the other hand, those the company has leased-in.

The number of vehicles owned during one year includes the vehicles owned the preceding year, minus those which were scrapped because they had reached the limit of their lifetime; this scrapping of vehicles takes place automatically at the beginning of each year. The number of vehicles owned during one year also includes all or part of the new vehicles that the participant possibly decided to buy at the beginning of the year, as well as all or part of those he had possibly decided to buy at the beginning of the preceding year but whose delivery was postponed one year.

In other words, the delivery of vehicles ordered at the beginning of a year is carried out in one or two stages: the vehicles are delivered (and paid) immediately if their number is not greater than the number of vehicles scrapped at the same time, implying that the purchase agreement for the "old" vehicles included a replacement clause with immediate-delivery-upon-order of new vehicles; on the other hand, the vehicles ordered at the beginning of a year, in addition to these replacements, are only delivered (and paid) one year later, that is, at the beginning of the following year.

In summary, the number of vehicles owned during a year i is equal to the number of vehicles owned during the year i-1, minus those scrapped at the beginning of year i, plus all or part of those ordered at the beginning of year i, plus possibly all or part of those ordered at the beginning of year i-1 but whose delivery was delayed.

The equipment leased during a year can be of two types: (1) vehicles leased-in voluntarily by the participant, and (2) vehicles leased-in

unintentionally, i.e. which are "imposed on" the participant when those vehicles he owns and those leased-in voluntarily are insufficient to operate all services supplied. In other words, if a participant supplies intercity services which require more vehicles than he already owns or leases voluntarily, his company is automatically forced to lease additional vehicles. This imposed leasing is made at a price triple that of a voluntary leasing. All lease contracts are for one year only; they automatically terminate at the beginning of the following year.

The number of "necessary vehicles" is the minimum number of vehicles required to operate the services supplied by the company. It is a function of the workload imposed on the vehicles for the peak periods (see section 2.5.2), that is, a function of the hours of service performed during each such period, also taking into account the time wasted on the network (stops, leaving the garages, etc.) and the time spent on maintenance. This number N of vehicles is more precisely calculated with the following equation, which is explained in Appendix 3.

$$N = \text{S.I.G.E.} \left\{ \frac{\alpha \times 1.10 \times T}{10.5} \right\}$$

where T = total daily hours of service provided by the company

α = 1.15 for a rail or bus company

1.30 for a standard airline company

1.20 for a STOL airline company

and where S.I.G.E. stands for "the smallest integer greater than or equal to".

3.3.3 Age of Owned Vehicles

The table under this heading gives the age of vehicles the company owns. The maximum age is obviously equal to the vehicle lifetime indicated in the section listing the techno-economic features of the company.

3.3.4 Operating Statistics

This table supplies global statistics on the operations of the company and the number of passengers transported. Data on vehicle-hours, vehicle-kilometers, etc., deal only with the services actually rendered, exclusive of time and kilometers lost leaving garages, making stops in cities, etc.

3.4 FINANCIAL DATA

Data in the first three tables under the "Revenues", "Deductible Expenses", and "Financial Results" headings supply all the financial information relative to the activities of the company for the last year. The next three tables – "Financial Position", "Balance Sheet", and "Financial Statistics" – utilize some of this data to update the financial statements of the company and to compute various indicators of performance.

The following section presents some preliminary remarks about various basic financial notions used in JET-SET/2. The contents of the tables are then explained.

3.4.1 Preliminary Remarks

A bank line of credit is allowed each company at the end of each year. This line of credit is determined in relation to the value of the fleet of vehicles owned at that point, and it constitutes a threshold which the total debt of the company should theoretically not exceed. If, nevertheless, the company decides to borrow beyond this line, the bank will authorize the loan, but the part of the loan which exceeds the line of credit is only authorized at an "imposed rate" 5 points higher than the normal rate of interest.

Since two different rates of interest are applicable to loans, one normal, one imposed, the total debt of a company can consist of two parts: one debt where the interest is paid at the normal rate, and another debt where the interest is paid at the imposed rate.

At the beginning of each year, the loan a company takes out constitutes an entry of funds which is immediately added to its bank balance (deposit). The total debt is obviously adjusted accordingly. Immediately after that, the company must pay for its purchasing and leasing of vehicles. If its bank balance is insufficient, the company is then automatically obliged to raise a new loan from the bank. Such an automatic loan also constitutes an entry of funds, but since this is an unplanned loan that the company is forced to take out to settle accounts payable at the beginning of the year, this loan is only authorized at the imposed rate of interest even if it does not entail exceeding the line of credit. The debt at the imposed rate is accordingly increased.

It is only when these operations have taken place at the beginning of the year that the debt repayment possibly planned by the participant is made totally, or only partially if the available funds are insufficient. Obviously, if the company has been forced to borrow to pay the purchasing and leasing of vehicles, all the planned repayments of loans remain to be effected.

The total or partial repayment of loans possible at the beginning of the year goes first to discharge the debt at the imposed interest rate, and then, as far as possible, to pay off the debt at the normal rate. Any repayment which then still remains to be made is automatically postponed until the end of the year. If the funds available at that time permit the repayment to be made, this reimbursement also goes first towards any of the imposed rate debt still remaining, and then, possibly, towards the normal rate debt.

The bank balance (deposit) and the debt are thus adjusted at the beginning of each year, according to the participant's decisions. It is in relation to this new bank balance and this new debt that the bank calculates the amount of interest payable to and receivable from the company at the end of the year. The interest income received by the company from its bank balance (deposit) is calculated with a rate of 3 points smaller than the normal rate of interest on a debt.

After all the operations described above, the computer program moves the calendar ahead 12 months. The year end then leads to the calculation of the financial statements, including all revenues and expenses. If the revenues exceed all expenses, the company can then meet all or part of the planned debt repayment which possibly still remains; any possible surplus is added to the bank balance. If the company revenues are less than its expenses, the company must dip into its bank balance; if this is nil or insufficient, the company is automatically obliged to raise a loan at the imposed interest rate in order to balance its budget; in this case, any repayment possibly remaining to be made is not effected; obviously, the company is never forced to borrow to repay an existing laon.

The commentaries below follow the sequence of the tables.

3.4.2 Revenues

Revenues from operations correspond to ticket sales over the year, as well as to possible sales of passenger amenities (meals, drinks, baggage services, etc.) on board and in the terminals (see section 3.7.3).

The only other possible revenues of the company, besides the revenues from operations, are the "bank interests received"; as indicated above, this interest income is calculated on the bank balance as adjusted at the beginning of the year, with a rate of interest which is 3 points smaller than the normal interest rate applied to a debt.

The loans a company takes out constitute, obviously, an entry of funds, but this is not, strictly speaking, an annual revenue in the same way as revenues coming from services supplied or interests on a bank deposit. In

the same fashion, subsidies which the government may grant a company constitute revenues of a "special" nature related to the support that the government may wish to provide to this company. These possible loans and government subsidies are entered in the tables entitled "Financial Results" and "Financial Position".

3.4.3 Deductible Expenses

The preceding commentaries clarify several items in the table of deductible expenses, i.e. expenses which can be deducted from revenues for fiscal reasons. What follows completes these explanations.

The regular operating costs group together all the costs borne by the company for all of its yearly operations. The costs are subdivided into two categories, "energy costs" on one hand, and all "other costs" (equipment, maintenance, administration, etc.) on the other.

The cost of passenger amenities corresponds to expenses possibly invested by the company to improve the comfort and efficiency of services offered travelers on board and in the terminals (see section 3.7.3).

The purchase of vehicles by a company is an expenditure, but such an expenditure is never immediately entered in its totality in the corresponding annual budget. Amortization is a fiscal procedure by which costs of purchases are spread out over several years; within JET-SET/2, amortization is calculated on a straight-line basis over the service life of vehicles, and this amortization is listed in the deductible expenses in conformity with traditional accounting practices.

The vehicle leasing costs are obviously deductible in totality, for tax purposes. Leases are subdivided into two categories (see section 3.3.2): on the one hand, leases determined voluntarily by the participant, and, on the other, those which were automatically imposed on the participant (at triple the normal price) if he did not plan for a sufficient number of vehicles to ensure the services he had undertaken to supply.

The other deductible expenses concern the special studies and advertising campaign possibly ordered by the participant at the beginning of the year (see section 3.5), as well as the interests paid on the debt, if any.

3.4.4 Financial Results

The table under this heading presents the financial synthesis of the two preceding tables, including government subsidies and taxes. When the revenues of a company exceed its deductible expenses, that is, when the company actually generates a gross profit, no government subsidy is granted. On the other hand, in the reverse situation, that is when there is a gross loss, the government (i.e. the game master) can decide to award a subsidy considering that it is within his role to support services in the public interest, or for any other reason, but he may also decide not to intervene. As for taxes, they apply to the difference between the taxable revenues (table of section 3.4.2 plus government subsidies) and the deductible expenses (table of section 3.4.3) if this difference is a positive quantity.

The net profit which is presented in the conclusion of the table represents the actual gain (or loss) realized by the company during the year.

3.4.5 Financial Position

The table under this heading summarizes all the past activities of the company up to the updating of its banking situation (balance and debt) and re-assessment of the value of its vehicle fleet.

The update of the debt and bank balance is carried out by taking into consideration all revenues and expenses which involved movements of money. The amortization is thus added to the bank balance, since it was entered as a deductible expense in the calculation of the profit, but did not in fact entail any movements of money.

Bank loans and debt repayments were the subject of preceding remarks.

The total amount of purchases includes all the invoices the company must pay at the time of delivery of the vehicles ordered (see section 3.3.2). These invoices correspond to the vehicles ordered at the beginning of the year and immediately delivered because the orders corresponded to the replacement of vehicles that had attained their limit of serviceability (lifetime); they also possibly correspond to vehicles delivered at the beginning of the year but which were ordered the previous year beyond the number of vehicles to be replaced at that time.

The debt includes the debt at the normal interest rate and the debt at the imposed rate; the total debt is equal to all loans undischarged ever since the company came into existence. The line of credit has been the subject of preceding commentaries.

3.4.6 Balance Sheet

The table under this heading offers a complete financial balance sheet of the company, including the value of its equipment, which is assumed here to be limited to vehicles owned.

The residual value of the vehicle fleet (i.e. its resale value) consitutes, besides the bank balance, a capital which should be taken into account when assessing the financial position of the company during the simulation session and at its end. This value of the fleet is determined by the age of the vehicles owned, their lifetime and their purchase price when new.

3.4.7 Financial Statistics

This table sets out, in the form of performance indicators, some of the results presented in preceding tables.

3.5 SPECIAL STUDIES

At the beginning of each year, a participant can decide to entrust to specialists within his company, or to consultants, an advertising campaign or some special studies. The results of an advertising campaign are, as in real life, difficult to measure; in fact, they are implicitly observable in the passenger traffic. On the other hand, it is in the form of tables that the results of the special studies requested by a participant explicitly appear.

These special studies are of four types:

3.5.1 Trip Survey

This table specifies the level of the demand for transportation for each pair of cities, i.e., the total number of persons who, over the year, traveled between these two cities by public transport and by car.

The table also specifies the proportions of business trips, and trips for other reasons, between each pair of cities (see section 2.5.3).

3.5.2 General Market Structure

This table specifies the global distribution of the transportation supply and demand among the different companies and the automobile mode.

3.5.3 Detailed Market Structure

This table indicates, for each city pair, how the transportation demand relative to the two classes of travelers (business and others) was distributed among the different companies and the automobile mode.

3.5.4 Detailed Review of the Company's Activities

This table summarizes in detail all the operations and passenger traffic of the company which ordered the study, for each pair of cities where the company has supplied services during the year.

3.6 ECONOMIC INDICATORS FOR THE COMING YEAR

In section 3.7, the participants are requested to make various decisions for the coming year. Before making these decisions, it is normal that their companies collect certain information from financial institutions and from the government. This information specifies the normal rate of interest which will apply to bank loans during the coming year, the interest rate which will apply to bank deposits, and the income tax rate.

3.7 DECISIONS FOR THE COMING YEAR

Having taken note of the results relative to the past year and of the economic indicators for the coming year, each participant must make various decisions, completing a form at the end of the annual report. The participant then gives this form to the game master or he, himself, enters his decisions on the keyboard of the computer.

3.7.1 Choice of Services

In the case of a deregulated situation (see section 2.4), participants can freely enter and leave any market (city pair), and there are no constraints on fares and frequencies of services.

On the other hand, in a regulated situation, a company which is not serving a city pair at the outset of the simulation session can never decide to serve it, and inversely, a company which at the outset provides services to a city pair can never decide to completely cancel its services to this city pair: the frequency of service must remain at least equal to 1 (in each

direction). Besides this, in a regulated situation, fares and frequencies must respect regulations on the maximum increase and decrease permitted. These constraints are indicated to participants just ahead of the table to fill out about fares and frequencies; if the constraints are not respected, an adjustment of the participant's decisions will be made automatically during the execution of the simulation program.

a) Variation in fares

The maximum permitted increase and reduction in fares are set out in percentages. For example, if a fare existing during a year is $4.20, a maximum permitted increase (decrease) of 50% determines an upper (lower) bound equal to $6.30 ($2.10) for the fare of the following year.

If one of the existing fares is under $1.00 (something which is improbable but not impossible), the corresponding upper bound is calculated as if the fare was in fact equal to $1.00; therefore, for a permitted increase of 50% for example, any fare under $1.00 determines an upper bound of $1.50, even if this fare is zero.

b) Variation in frequencies

The maximum permitted increase and decrease in frequencies of services are similarly expressed in percentages. Since only whole numbers are possible to express a frequency, the upper and lower bounds obtained by applying the permitted percentage of variation are rounded off to the nearest integer greater than or equal to the value obtained. For example, if the frequency during a year is 5, a maximum permitted increase (decrease) of 50% determines an upper (lower) bound equal to 8 (3) since the value of 7.5 (2.5) is rounded off to the nearest integer greater than or equal to this value.

A reminder: nevertheless, in a regulated situation, independent of the maximum permitted increase and decrease, the minimal service frequency that

a company must maintain between two cities is one departure per day (in each direction). Furthermore, a variation of 1 unity is always allowed, except if the variation permitted is 0% or if the change in question is from 1 to 0 (minimal frequency = 1).

A reminder also: the frequencies supplied must take into account the fleet of vehicles. If there is an insufficient number of vehicles, there will be an imposed leasing of vehicles at triple the price of a voluntary leasing.

3.7.2 Decisions about the Vehicle Fleet

As previously indicated, vehicles that the company decides to buy will be delivered immediately if they are intended as replacements for vehicles automatically being scrapped because of age; in other words, the old purchase agreements are assumed to include a replacement-with-no-delay-of-delivery clause. Vehicles that a company decides to buy over and above the stock to be replaced will be delivered (and paid) one year later.

A reminder: vehicle leases are for one year only.

3.7.3 Decisions about Passenger Amenities

To improve the comfort of travelers and the quality of their travel, and thereby attract more clients, a transportation company generally offers special amenities which are sometimes free but more often paid by travelers in whole or in part. For example, this involves offering meals and drinks or earphones on board, and insurance services and baggage handling in the terminals.

Each participant has the choice between three levels of "passenger amenities". Level 1 corresponds to "normal passenger amenities" which are free and which do not entail any additional cost upon the company, neither any particular effect that might attract customers. On the other hand, levels 2 and 3, respectively the "improved" and the "extra" levels of passenger

amenities, entail additional costs for the company, as well as additional revenues since the passengers have to pay for these special amenities. Furthermore, these latter two levels of passenger amenities somewhat improve the appeal of the company, and thus serve to attract more clients, just as would a reduction of fares or an increase in frequencies of services.

For given transporation services, the additional costs and revenues of the "extra passenger amenities" (level 3), just like their attraction effect on travelers, are greater than those of the "improved amenities" (level 2). Additional costs are a function of the hours of service provided by the company, with the unit costs as indicated on the form to be filled in. Additional revenues are a function of the number of transported passengers and the duration of their trips; they are roughly proportional to revenues from ticket sales. The effects of attraction are taken into account in the simulation of choices made by travelers.

3.7.4 Decisions about Special Projects

Each company can decide to embark on an advertising campaign with a view, similarly, to improving the company's appeal to the public. The cost of such a campaign is estimated at 1.5% of operating revenues receivable by the company. The resulting attraction is taken into account in the simulation of choices made by travelers.

The costs of other special studies which a company can also undertake on the demand for transportation (trip survey), on the general market structure, on the detailed market structure, and on the details of its own operations (see section 3.5) can be respectively assessed at 1.2%, 0.5%, 1.0% and 0.1% of operating revenues.

3.7.5 Decisions about Banking Operations

As indicated previously, the part of a loan which exceeds the line of credit is only authorized at an imposed rate of interest (5 points higher than the normal rate).

At the beginning of the year, a loan at the imposed interest rate will similarly be imposed on any company whose bank balance and voluntary loans are insufficient to receipt the purchase and lease bills (voluntary and imposed leases). At the end of the year, also, a compulsory rate loan can be imposed on a company which is not able to pay all its expenses.

A debt repayment obviously cannot exceed the amount of the debt. Besides that, all or part of the planned repayment will possibly be rescinded if during the coming year the necessary funds are not available or not sufficient (see section 3.4.1).

4. ANNUAL REPORT GIVEN TO THE GAME MASTER

Each report intended for the game master contains most of the information included in the reports given to the participants, with minor additions and modifications. It also contains a list of decisions to make for the coming year and for the year after that, as well as a synthesis section recapitulating the results of past years, provided the game master has ordered the production of such a synthesis.

The master's report always starts with one or two of the three graphs presented at the head of the reports given to the various participants.

In game situations 1 and 2, and also in regulated situation 3, two graphs always appear: the one entitled "Road and Rail Infrastructure", and the other entitled "Complete Service Network". In a deregulated situation 3, only the graphic entitled "Road and Rail Infrastructure" appears. The other graphics present in the participants' reports do not appear in the master's report, because in general they differ from one participant to another.

Besides, in the case of situation 3, the only information that appears in the master's report concerning companies without participants (fixed companies) is the information which describes the services they offer.

Other information (on passenger traffic, revenues, market shares, etc.) is excluded since such information varies from one participant's report to another. In brief, in situation 3, one deals with different "parallel simulations": the master's report only contains information common to all. Other data must be consulted in the participants' reports.

The commentaries below follow the sequence of the different sections appearing in the master's report.

4.1 GENERAL DATA

This section is identical to the corresponding section in the participants' reports (see section 3.1), with minor additions and modifications.

The table entitled "Identification of Companies" identifies the names of participants in charge of companies. The "fixed" companies, i.e. those possibly present in a simulation but without participants to manage them, are identified by asterisks in place of the names of participants.

The table entitled "Direct Services Supplied by all Companies and Corresponding Data for the Automobile" is identical to the one given in the report of each participant. However, in the case of game situation 3, each page of the table is divided into two parts. The first describes the transportation services of the companies managed by the participants in "parallel simulations", and the second part describes the services of the other companies, that is, those that are "fixed" in each of these "parallel simulations".

The table entitled "Economic Indicators" specifies the rates of government subsidies which may possibly have been offered to companies during the year. Section 4.5.2 indicates how these rates are utilized to calculate the subsidies in question. In situation 3, the only subsidy rates presented are

those of the companies managed by the participants (as indicated previously, most of the data about the other companies, i.e. those that are "fixed", is not presented in the master's report since it varies from one "parallel simulation" to another).

4.2 FINANCIAL DATA

This section gathers diverse data presented under corresponding headings in the participants' reports (see section 3.4).

4.3 DETAILED STRUCTURE OF THE MARKET AND OF OPERATIONS (Situations 1 and 2) DETAILED REVIEW OF THE ACTIVITIES OF THE PARTICIPANTS' COMPANY (Situation 3)

In game situations 1 and 2, this section presents the same data as two of the "Special Studies" sections in the reports of the different participants (see sections 3.5.1 and 3.5.4), whether or not the participants ordered these studies. In situation 3, only one of the two sections in question is provided and the data presented is limited to the company managed by participants.

4.4 ECONOMIC INDICATORS FOR THE COMING YEAR

This section is identical to the one in the participants' reports (see section 3.6).

4.5 DECISIONS FOR THE COMING YEAR

This section of the report contains a form listing the decisions the game master must make and which will be in effect during the year about to begin.

4.5.1 Decisions about Demography

The demographic growth rate to choose for each city should be reasonable in order to avoid absurd situations. The rate may be given a negative value.

4.5.2 Decisions about Government Subsidies

It is under this heading that the game master can decide to subsidize certain companies experiencing difficulties. The subsidy rate he selects for a company will determine the amount of the subsidy needed to cover partially or totally (or even more) the financial losses the company will possibly suffer. In other words, this subsidy rate will be applied to the difference between the total revenues of the company over the coming year and the sum of its deductible expenses, provided this difference is negative; thus, a subsidy will be granted only if the company is actually in difficulty: a rate of subsidy less than (or equal to) 100% will cover in part (or totally) the financial loss; a rate higher than 100% will do more than just cover the loss. On the other hand, if the revenues are greater than the deductible expenses, the subsidy will be nil no matter what rate has been chosen. Incidently, it should be noted that if there is actually a subsidy, it is considered as a taxable income.

4.5.3 Decisions about the Price of Energy

The choice of the rate of variation in the price of energy will determine the variation in unit operating costs relative to the consumption of energy by each company (and the automobile mode), between the last year and the year about to begin. This rate can be negative.

4.6 DECISIONS FOR THE YEAR SUBSEQUENT TO THE COMING YEAR

This section of the report contains a form listing the decisions the game master must make, and which will be in effect during the year following the year about to begin. These decisions will be communicated to participants in the reports they will receive at the end of the year about to begin.

In other words, decisions taken under this heading at the beginning of a year i will be communicated to participants at the end of the year i and will be in effect during the year i+1.

4.6.1 Decisions about the Regulation of Transportation

It is under this heading that the game master, in the case of a regulated situation, may impose certain limits on permissible variations in fares and frequencies of services. These constraints will have to be respected by the variations in fares and frequencies between the coming year and the subsequent year.

4.6.2 Decisions about Economic Indicators

Under this heading, the game master determines the rates of interest and of imposition which will be in effect during the year following the one about to start. The interest rate that the game master selects here is the one which will apply to the bank balance (deposit) of each company, i.e. the rate which will determine the amount of interest to be paid to the company. The normal interest rate relevant to the companies' loans (debts) will always be automatically adjusted to be equal to the selected rate plus three points. The interest rate relevant to the imposed loans will be equal to the normal interest rate on loans plus 5 points.

4.7 SYNTHESIS

This section of the report, provided the game master has ordered it, recapitulates the evolution of the activities of the different companies over the previous simulated years (this synthesis may go back a maximum of 7 years).

The first two tables – "Evolution of Operations" and "Financial Evolution" – repeat certain data already given in the reports of previous years. When,

for certain data, the rates of variation are specified, these rates measure the variation of the data from one year to the next.

The third table – "Evolution of Services to Travelers" – gives, for each year and each city pair, the cost and the duration of, on one hand, the most rapid itinerary, and on the other hand, the least expensive. (In situation 3, the synthesis section includes such a table for each participant, i.e. one for each of the "parallel simulations".) This data only deals with the itineraries relative to the public means of transportation (i.e. excluding trips by automobile) and it includes the access and egress costs and times, as well as the costs of transfer and waiting times in intermediate cities, if any (see Appendix 1). If, for certain pairs of cities, asterisks (****) appear in place of costs and times, that indicates that all travelers went by car, either because there was no public means of transport, or because all possible itineraries of public transportation were considered really uninteresting by travelers.

APPENDIX 1

Supplementary times and costs incurred by passengers on train, bus and plane over and above the actual travel times and fares

Whatever means of public transportation is utilized, the simulation of the choices and behaviour of the travelers takes into account that they bear the times and costs of accessing and leaving the network, i.e. the duration and cost of movement between the place of origin and the departure terminal, as well as those between the arrival terminal and the place of destination. These access times and costs on the one hand, and the egress times and costs on the other, are assumed to be respectively equal to:

- 15 minutes and $7 (in 1990 dollars) for a rail or bus terminal;
- 30 minutes and $15 for a standard airline terminal;
- 20 minutes and $10 for a STOL airline terminal.

Moreover, for itineraries involving passages (stops) in intermediate cities, with or without a change of company, the simulation takes into account the waiting time between one service and the next, as well as the transfer cost if there is a change of terminal. The transfer costs are assumed equal to:

- $5 (in 1990 dollars) between a rail terminal and a bus terminal;
- $18 between a rail or bus terminal and a standard airline terminal;
- $10 between a rail or bus terminal and a STOL airline terminal;
- $10 between a standard airline terminal and a STOL airline terminal.

As for the average waiting time between one service and the next, it is estimated as a function of the daily frequencies of the two services. Thus it can be very long (several hours) if the frequencies are low.

APPENDIX 2

Automobile costs

Automobile costs are based on unit values, in 1990 dollars, equal to $4.30/hr for fuel (5.58 cents/km, assuming an average speed of 77 km/hr) and $30.00/hr (38.96 cents/km) for other costs (insurance, maintenance, depreciation, tires, etc.), making a total of $34.30/hr (44.54 cents/km). These costs can be modified by the game master at the start of each simulation session. Besides, the cost of fuel can vary each year as a function of decisions made by the master about the variation in the price of energy.

Of course, when comparing automobile costs with ticket prices by bus, rail or air, most people only take the cost of fuel into consideration, but realistic people also take into account these other costs mentioned above, or at least, a part of them. In the simulation of choices made by travelers, one assumes that 10% of these other costs are taken into consideration over and above the cost of fuel. In other words, provided that the game master does not modify the unit costs given above, nor the price of energy, the simulation hypothesizes a "subjective" automobile cost equal to $4.30/hr plus $3.00/hr, i.e. $7.30/hr (9.48 cents/km).

APPENDIX 3

Calculation of the number of necessary vehicles

The minimum number of vehicles necessary to operate the services supplied by a company is the number of vehicles required to provide services during each peak period of the day, i.e., to be able to supply 1/3 of the total daily hours of service over 3 hours and 30 minutes (see section 2.5.2). To ensure these rush hour services, the company must take into account the fact that:

- besides the actual time spent moving between the different pairs of cities, the vehicles spend time stopping in cities, leaving garages, making empty movements (for example going from one service to another), etc.; in brief, they sustain a series of "time lost" that must be added to the travel time itself;
- in addition, the company must allow for additional vehicles to permit periodic and regular maintenance, since it is not always possible to carry out all maintenance operations outside of rush hours.

The total daily hours of service provided by a company on its network is easily calculated by the following equation:

$$T = 2 \times \left\{ \sum_{i=1}^{7} \sum_{j=i+1}^{7} t_{ij} \times f_{ij} \right\}$$

where t_{ij} = traveling time of a vehicle from city i to city j (in hours);

f_{ij} = daily frequency of service from i to j.

The factor 2 appears in this equation to account for movements in both directions between each pair of cities.

If β represents the percentage of time which must be added to the actual travel time to take into account the "time lost", the total number TN of hours spent by vehicles in service on the whole network during a peak period is:

$$TN = \frac{1}{3}\left(T + \frac{\beta}{100}\,T\right) = \alpha \times T/3 \text{ with } \alpha = 1 + \beta/100.$$

If one assumes that the hours allowed for vehicle maintenance during one peak period correspond to 10% of the hours spent by vehicles in service on the network over the same period, the total number TU of hours of vehicle use during a peak period (vehicles on the network and vehicles in maintenance) is:

$$TU = TN + 0.10\ TN = \frac{\alpha \times 1.10 \times T}{3}$$

In a peak period, a vehicle in service is normally used full time, i.e., during the 3.5 hours of this period. Also, one can assume that on the average the maintenance of a vehicle takes at least 3.5 hours and that each vehicle in maintenance during a peak period is, therefore, also being "used" on a full-time basis, i.e. for 3.5 hours. The total number of vehicles thus necessarily "occupied" during a peak period, i.e. the minimum number of vehicles necessary to the company, is consequently determined by the following equation:

$$N = \text{S.I.G.E.}\left\{\frac{TU}{3.5}\right\} = \text{S.I.G.E.}\left\{\frac{\alpha \times 1.10 \times T}{10.5}\right\}$$

where S.I.G.E. stands for "the smallest integer greater than or equal to"

T = total daily hours of service

$\alpha = 1 + \beta/100$

In the calculations, one assumes that

- for a rail or bus company, $\beta = 15\%$, thus $\alpha = 1.15$
- for a standard airline company, $\beta = 30\%$, thus $\alpha = 1.30$
- for a STOL airline company, $\beta = 20\%$, thus $\alpha = 1.20$